

TO:

FROM:

SUBJECT: Optical System Performance

DATE: 19 August 1964

STAT

Background

Following assembly and alignment of the enlarger optical system early in May, 1964, photographic testing was started to check the optical performance of the system. It very quickly developed from these tests that performance was excellent in the central region of the image field, but that degradation occurred in the outer portion. Further tests quickly established that Lens No. 1 (projection lens) was the element of the system causing the degradation.

There followed an extended period of tests of various types on Lens No. 1 in an attempt to ascertain the nature of the deficiency, which proved very elusive. Details of the various test procedures and results are described in Engineering Note Book No. 2125, and detailed memorandum presently in preparation.

Briefly, it appears now that the original difficulties with Lens No. 1 were in part due to an accumulation of minor inaccuracies in the mounting of the elements, but were also in part due to the optical design. Considerable improvement was made in the lens by remounting the elements using improved means for obtaining concentricity and with some slight air space adjustments. It appears probable that the resolution problems remaining in the lens after final reassembly (to its present condition) largely reflect conditions remaining in the optical design.

Aerial Image Tests

Following final reassembly of the lens, further optical tests were made (using laser star image techniques) and (on June 25) after reassembly of the lens in the system, visual 3-bar target tests were made. In these tests, the emphasis was on incoherent (sodium) light observations, since the purpose was to check the optical quality of the system, but some tests were made using a high coherence. The results under the two conditions are very similar when the effects of spurious resolution are discounted.

The target used in tests described in the following was the AF 3-bar pattern reproduced on a 35-mm film strip, at a 25:1 reduction over the original. This provides a repeated pattern which can provide six positions over a diagonal of the field, and provide a maximum target resolution up to 400 lines/mm. Images were observed through a microscope fixed to the camera back, and rotation of the lens between observations enabled the field to be well explored.

Declass Review by NIMA / DoD

Typical results are listed in the following table. The resolution figures given (in lines/millimeter) are those for which both radial and tangential lines could be resolved. In general, except in the center of the field, the radial line groups were better defined than the tangential groups by about 50 lines/millimeter.

Field Position (distance from center in inches)	Field Quadrants			
	0	1	2	3
1.0	400+	400+	400+	400+
1.9	400+	400+	400+	400+
2.35	357	357	319	319
3.30	352	352	352	383
3.80	212	200	200	212
4.35	200	190	200	225
5.80	200	200	200	212

The theoretical aperture limitation for the system in incoherent light is slightly over 40 lines/millimeter. The above results show that the resolution over a central circle (at the film plane) of about 6 inches diameter is excellent, but with substantial degradation outside of this area. The main identifiable error contributing to image degradation in the field was obviously an astigmatic effect.

Photographic Tests

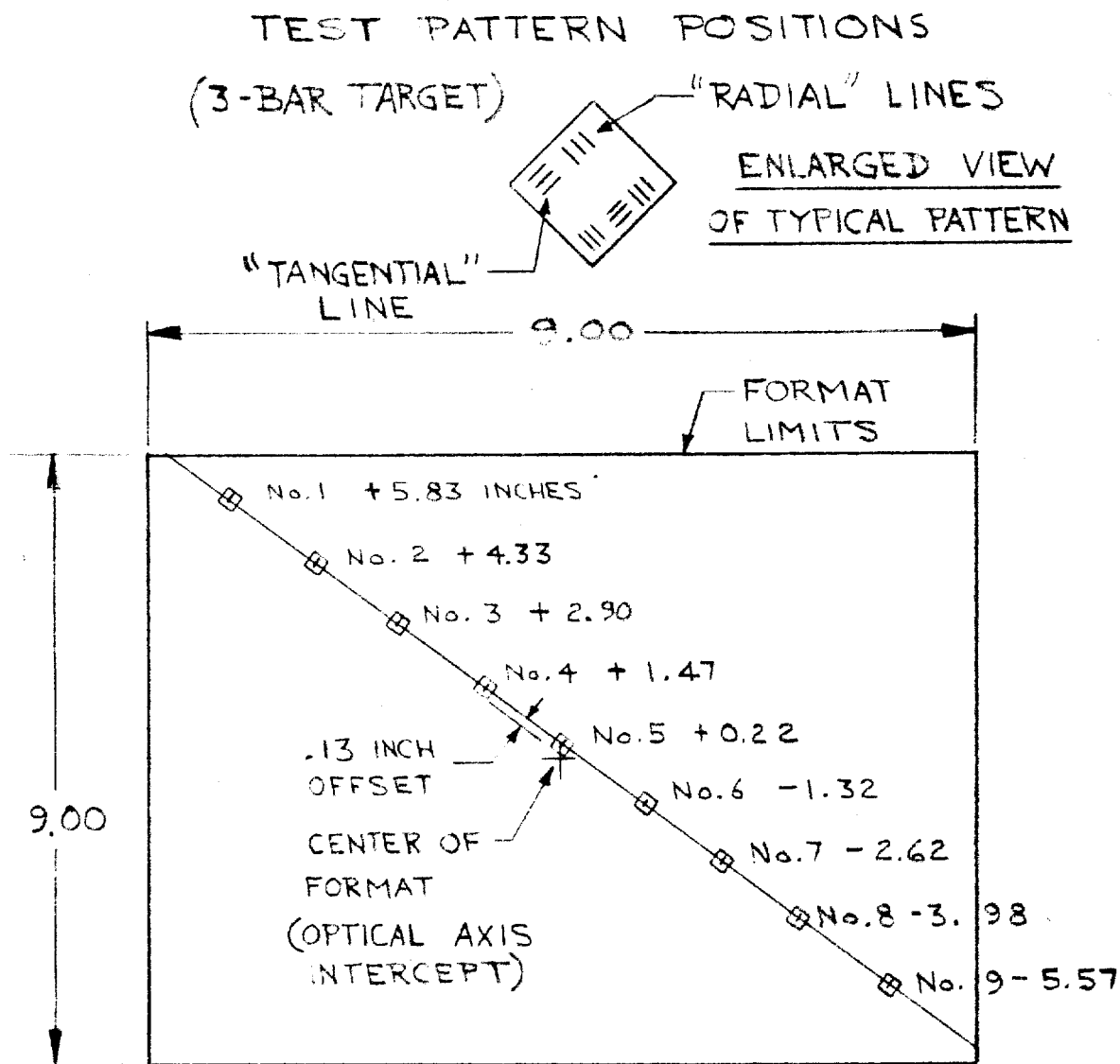
Following the above visual tests, repeated photographic test runs were made using various targets and under various degrees of coherence in both laser and sodium illumination. Qualitatively, the results are similar to visual observations, but with a reduction in the numerical results in lines/millimeter resulting from the film function.

The following graphs, taken from a photographic run of August 6 were reduced primarily as an aid in evaluating the correlation of the system performance with optical design data. However, the results are characteristic, and descriptive of the present optical performance of the enlarger.

The runs were made using the reduced target strip film mentioned above. The illumination was sodium at 80 percent coherence.

COHERENT LIGHT ENLARGER

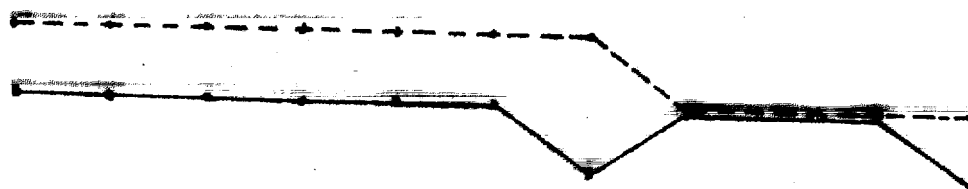
RESOLUTION OF THREE BAR, HIGH CONTRAST TARGETS



FORMAT OUTLINE SHOWING
POSITIONS OF TEST PATTERNS
(NUMBERS GIVEN ARE RADIAL
DISTANCES FROM FORMAT
CENTERS IN INCHES)

TANGENTIAL

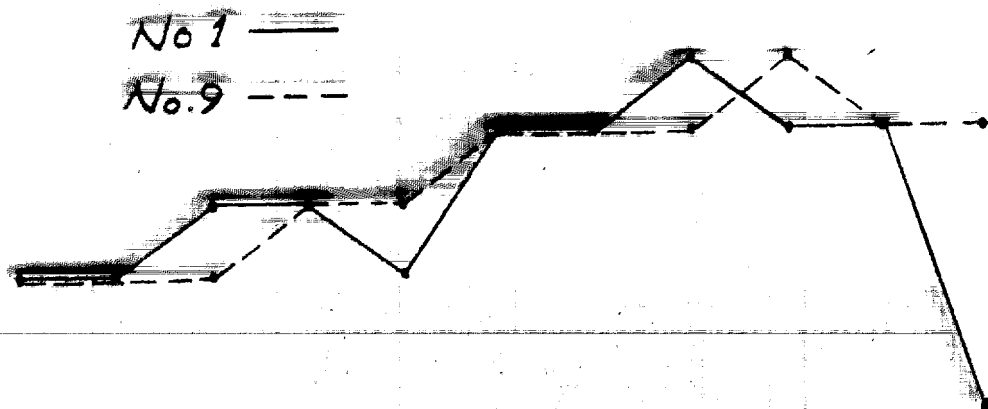
No 1 ———
No 9 - - - -



RADIAL

RADIAL DISTANCE
FROM FORMAT CENTER
(INCHES)

NO 1 +5.83
NO 9 -5.57



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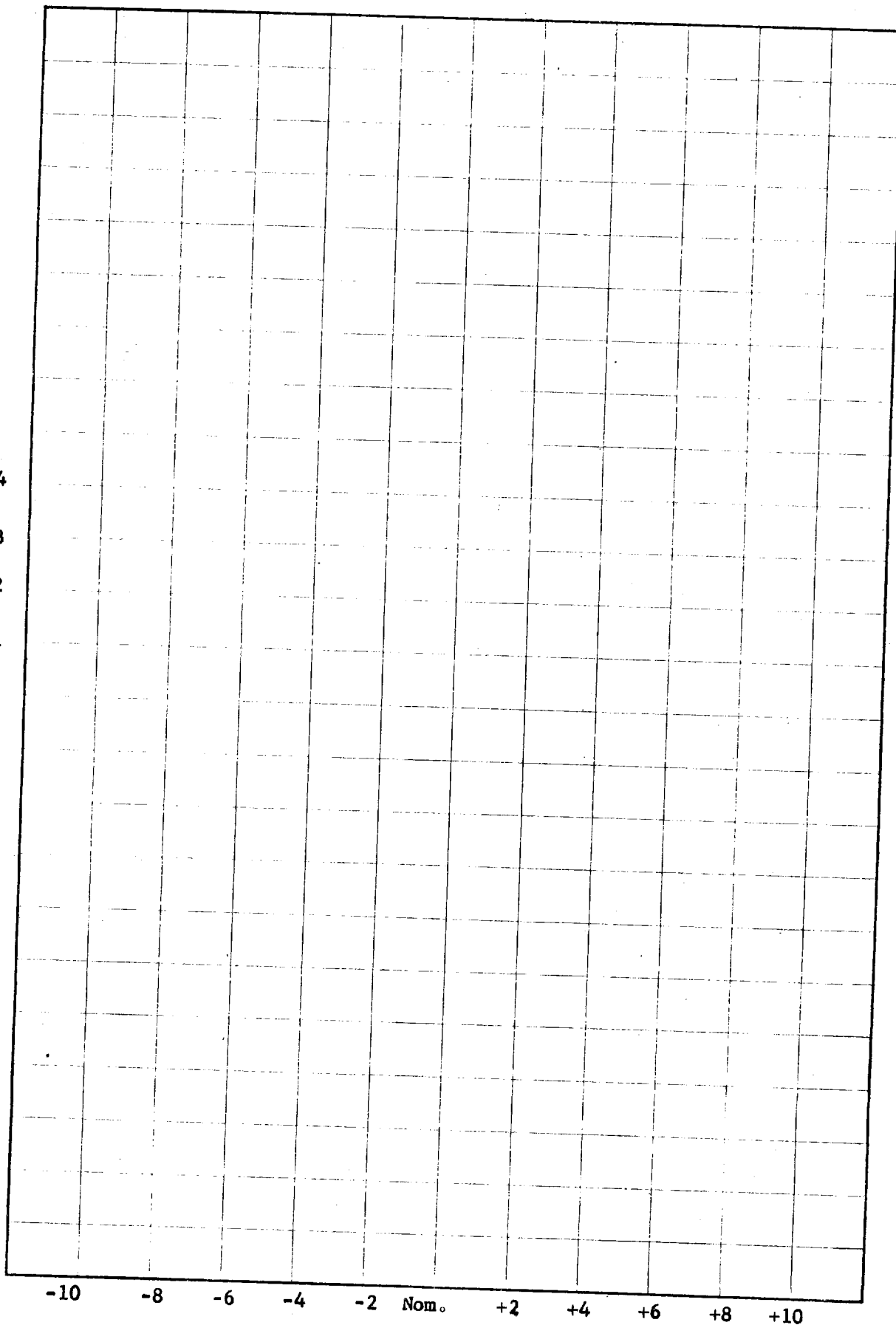


12 21 23 DIVISIONS.

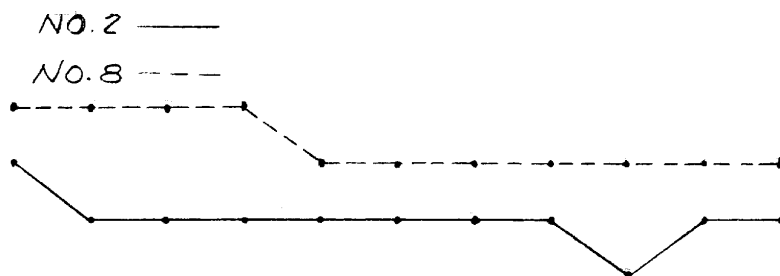
Lines/Millimeter

Pattern Number

- 283 3-4
- 252 3-3
- 225 3-2
- 200 3-1
- 178 2-6
- 159 2-5
- 141 2-4
- 126 2-3
- 112 2-2
- 100 2-1
- 89 1-6
- 80 1-5
- 70 1-4
- 63 1-3
- 56 1-2



TANGENTIAL



ILLEGIB

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Lines/Millimeter

Pattern Number

283 3-4

252 3-3

225 3-2

200 3-1

178 2-6

159 2-5

141 2-4

126 2-3

112 2-2

100 2-1

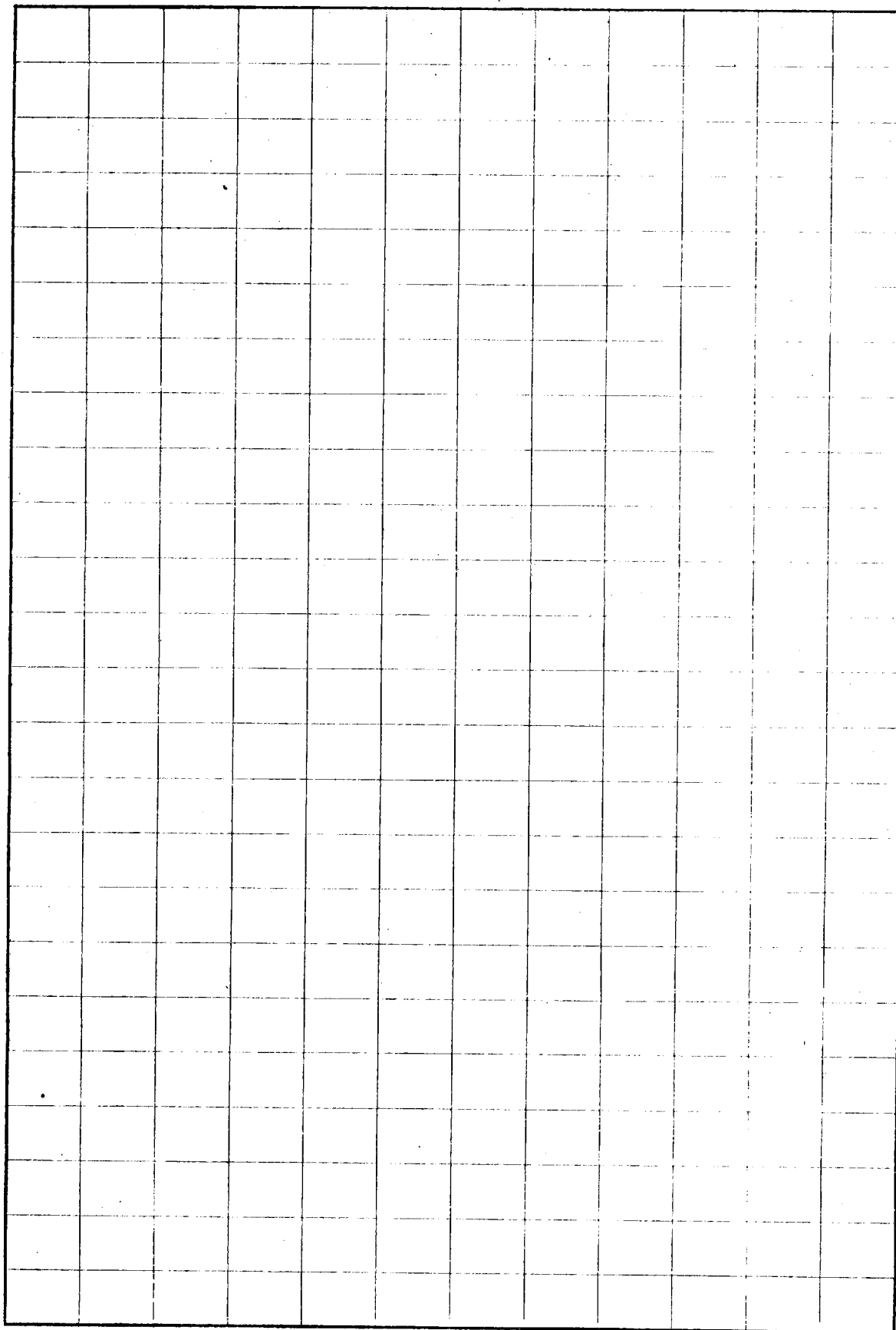
89 1-6

80 1-5

70 1-4

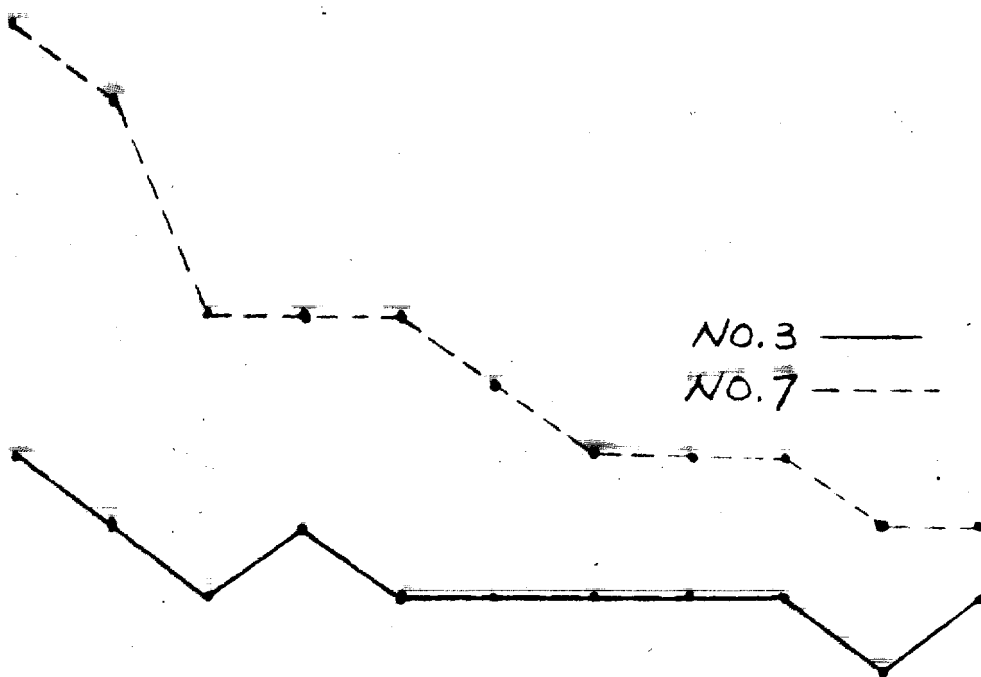
63 1-3

56 1-2



-10 -8 -6 -4 -2 Nom. +2 +4 +6 +8 +10

TANGENTIAL



RADIAL

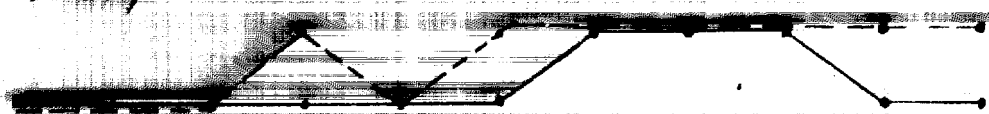
RADIAL DISTANCE
FROM FORMAT CENTER
(INCHES)

NO. 3 + 2.90

NO. 7 - 2.62

NO. 3

NO. 7

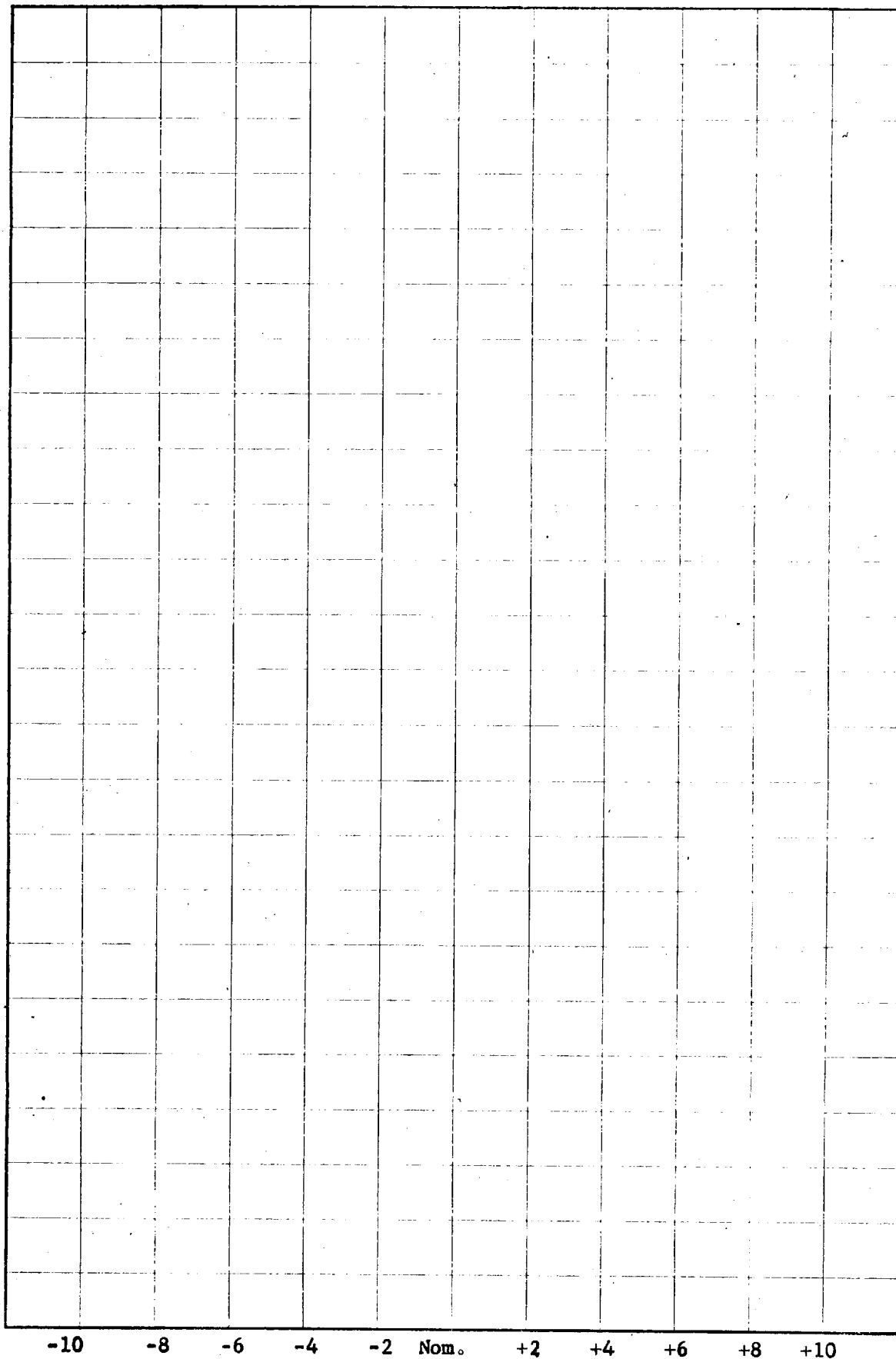


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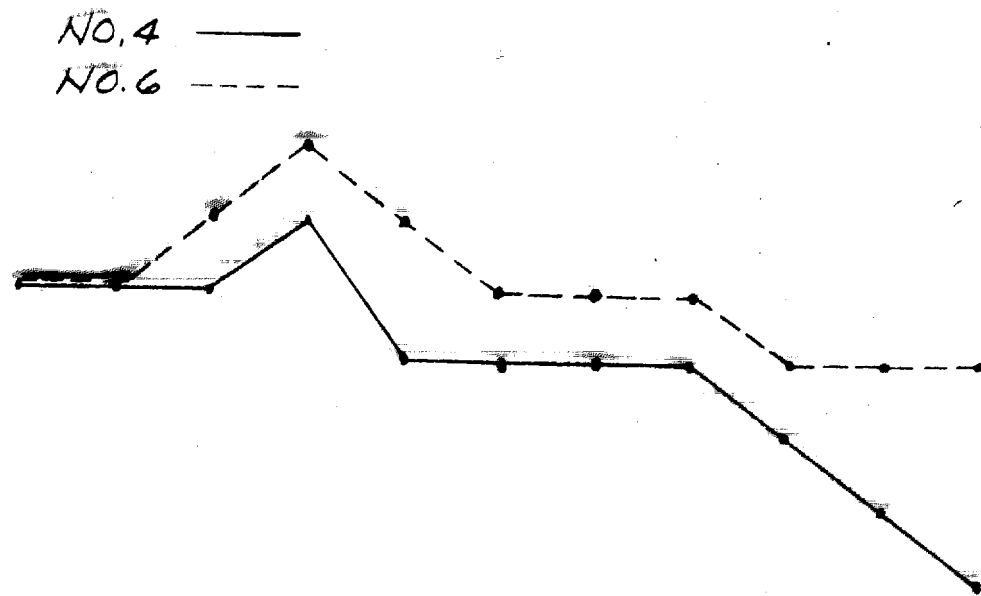


NO. 3184, 12 BY 24 DIVISIONS.

Lines/Inch	Pattern Number
283	3-4
252	3-3
225	3-2
200	3-1
178	2-6
159	2-5
141	2-4
126	2-3
112	2-2
100	2-1
89	1-6
80	1-5
70	1-4
63	1-3
56	1-2



TANGENTIAL



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Lines/Millimeter

Pattern Number

283 3-4

252 3-3

225 3-2

200 3-1

178 2-6

159 2-5

141 2-4

126 2-3

112 2-2

100 2-1

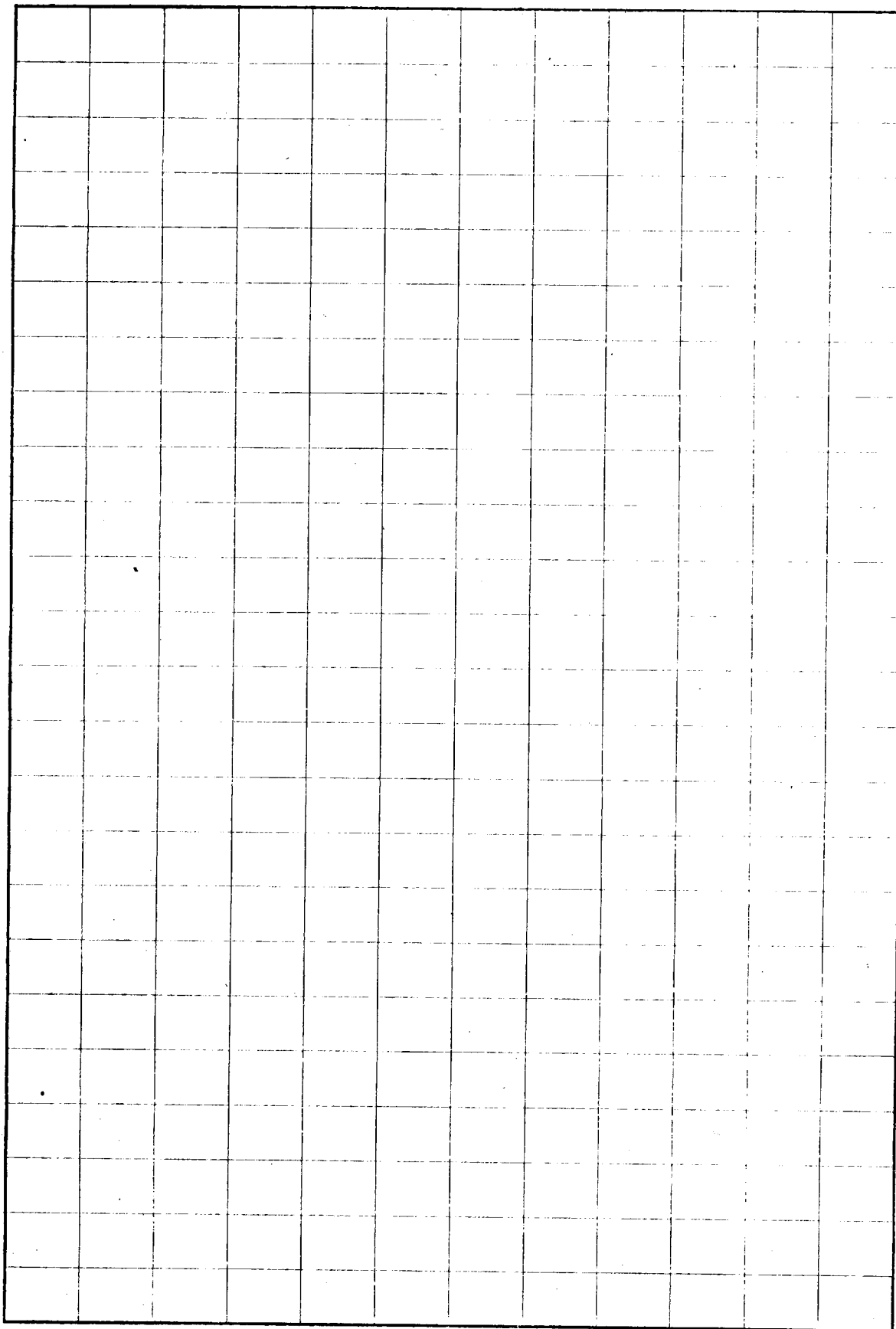
89 1-6

80 1-5

70 1-4

63 1-3

56 1-2

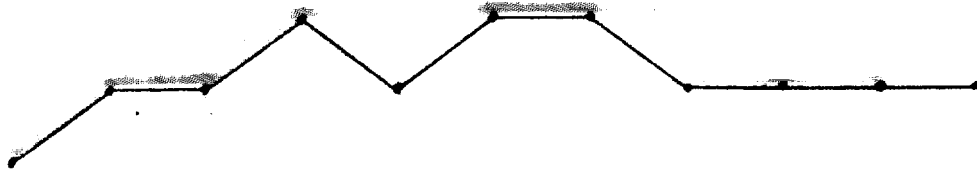


-10 -8 -6 -4 -2 Nom. +2 +4 +6 +8 +10

NO. 5184. 12 BY 24 DIVISIONS.

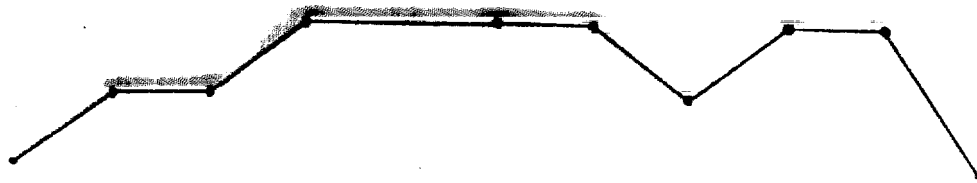
TANGENTIAL

No. 5



RADIAL

RADIAL DISTANCE
FROM FORMAT CENTER NO. 5 - 0.22
(INCHES)



CODEX BOOK COMPANY, INC. NORWOOD, MASSACHUSETTS



Lines/Millimeter

Pattern Number

283 3-4

252 3-3

225 3-2

200 3-1

178 2-6

159 2-5

141 2-4

126 2-3

112 2-2

100 2-1

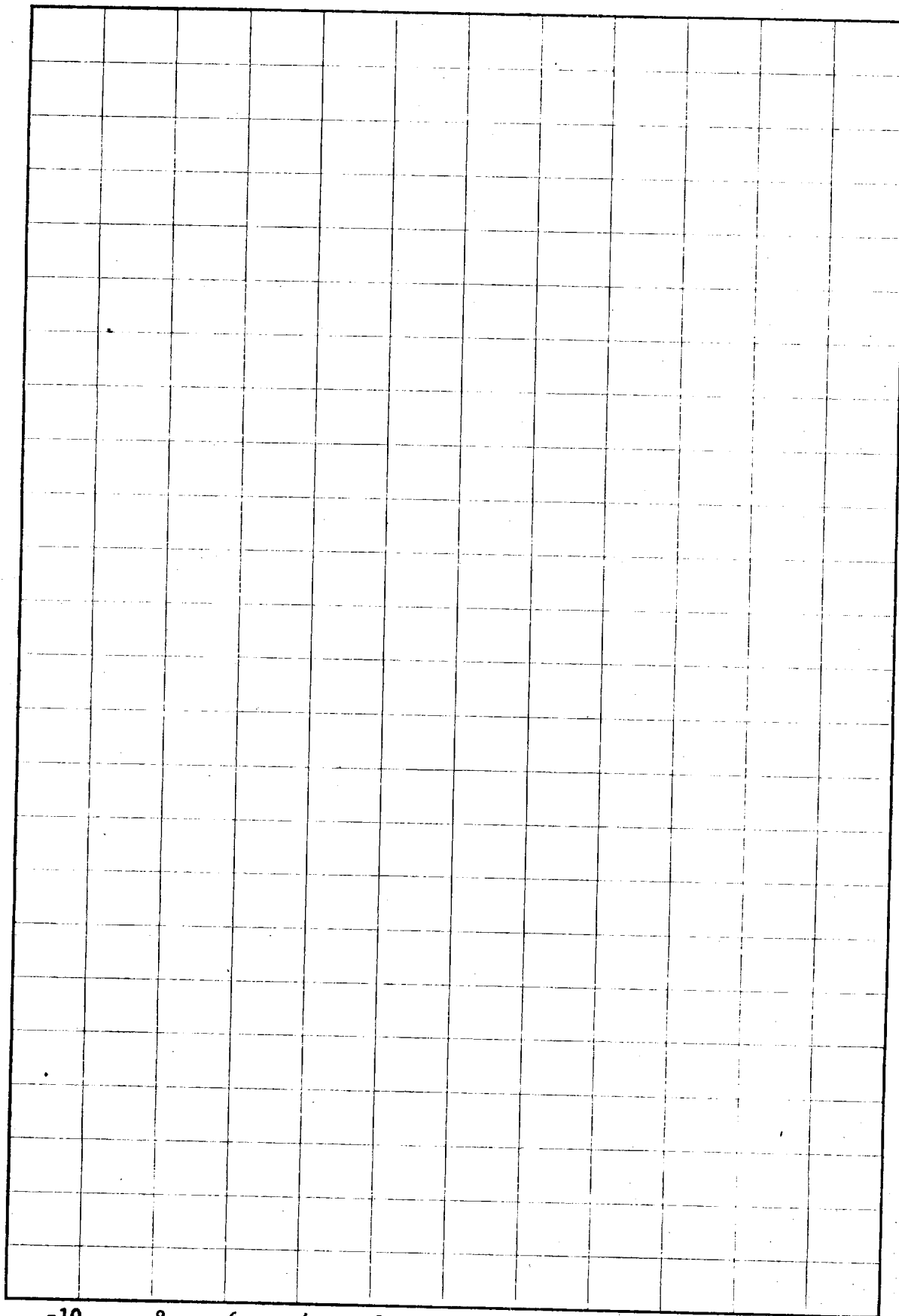
89 1-6

80 1-5

70 1-4

63 1-3

56 1-2



-10 -8 -6 -4 -2 Nom. +2 +4 +6 +8 +10